10-31-05

AF
IFW

Express Mail Label
No. EV 7756293 US

MEMC 99-1250/2441.1
PATENT

OIPE
OCT 28 2005
PATENT & TRADEMARK OFFICE
IAP78

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Hariprasad Sreedharamurthy et al. Art Unit 1765
Serial No. 10/039,459
Filed November 7, 2001
Confirmation No. 1061
For APPARATUS AND PROCESS FOR THE PREPARATION OF LOW-IRON SINGLE CRYSTAL SILICON SUBSTANTIALLY FREE OF AGGLOMERATED INTRINSIC POINT DEFECTS
Examiner Matthew J. Song

October 28, 2005

LETTER TO THE PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
P.O. BOX 1450
ALEXANDRIA, VIRGINIA 22313-1450

SIR:

This Letter responds to the Notification of Non-Compliant Appeal Brief dated July 28, 2005. Applicant submits herewith a Substituted Appeal Brief in conformance with 37 CFR 41.37 (c).

A check in the amount of $450 is enclosed for the two-month extension of time fee under 37 CFR 1.136 and 37 CFR 1.17(a) is also enclosed.

If there are any additional charges in this matter, please charge our Deposit Account No. 19-1345.

Respectfully submitted,

Richard A Schuth

11/01/2005 TBESHAH1 00000020 10039459
01 FC:1252 450.00 OP

Richard A. Schuth, Reg. No. 47,929
SENNIGER, POWERS, LEAVITT & ROEDEL
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400

RAS/DER/skd

OIPE IAP78 OCT 28 2005 PATENT & TRADEMARK OFFICE

FEE TRANSMITTAL

Application Number 10/039,459
Filing Date November 7, 2001
Confirmation No. 1061
Inventor(s) Hariprasad Sreedharamurthy et al.
Group Art Unit 1765
Examiner Name Matthew J. Song
Attorney Docket Number MEMC 99-1250/2441.1

METHOD OF PAYMENT

1. [ ] The Commissioner is hereby authorized to charge the indicated fees to Deposit Account No. 19-1345.

   [ ] The Commissioner is hereby authorized to charge any additional fees required under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1345.

   [ ] Applicant claims small entity status.

2. [X] Check Enclosed. The Commissioner is hereby authorized to charge any under payment or credit any over payment to Deposit Account No. 19-1345.

FEE CALCULATION

1. [ ] BASIC FILING FEE Subtotal (1) $__________
   (Type: ______________)

2. [ ] EXTRA CLAIM FEES Subtotal (2) $__________

   Total Claims _____
   Independent Claims _____
   Multiple Dependent Claims _____

3. [X] ADDITIONAL FEES Subtotal (3) $ 450.00

   [ ] Surcharge - late filing fee or oath
   [ ] Surcharge - late provisional filing fee or cover sheet
   [X] Extension for reply within 2nd month
   [ ] Notice of Appeal
   [ ] Filing a Brief in Support of an appeal
   [ ] Request for ex parte Reexamination
   [ ] Petitions to the Commissioner
   [ ] Submission of Information Disclosure Statement
   [ ] Recording each patent assignment per property
   [ ] Request for Continued Examination
   [ ] Other: ______________________________

TOTAL AMOUNT OF PAYMENT $ 450.00

Richard A. Schuth, Reg. No. 47,929 10-28-05
Date

RAS/skd

Express Mail Label No. EV 775629329 US

FEE TRANSMITTAL

Application Number 10/039,459
Filing Date November 7, 2001
Confirmation No. 1061
Inventor(s) Hariprasad Sreedharamurthy et al.
Group Art Unit 1765
Examiner Name Matthew J. Song
Attorney Docket Number MEMC 99-1250/2441.1

METHOD OF PAYMENT

1. [ ] The Commissioner is hereby authorized to charge the indicated fees to Deposit Account No. 19-1345.

   [ ] The Commissioner is hereby authorized to charge any additional fees required under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1345.

   [ ] Applicant claims small entity status.

2. [X] Check Enclosed. The Commissioner is hereby authorized to charge any under payment or credit any over payment to Deposit Account No. 19-1345.

FEE CALCULATION

1. [ ] BASIC FILING FEE Subtotal (1) $__________
   (Type: ____________)

2. [ ] EXTRA CLAIM FEES Subtotal (2) $__________

   Total Claims _____
   Independent Claims _____
   Multiple Dependent Claims _____

3. [X] ADDITIONAL FEES Subtotal (3) $ 450.00

   [ ] Surcharge - late filing fee or oath
   [ ] Surcharge - late provisional filing fee or cover sheet
   [X] Extension for reply within 2nd month
   [ ] Notice of Appeal
   [ ] Filing a Brief in Support of an appeal
   [ ] Request for ex parte Reexamination
   [ ] Petitions to the Commissioner
   [ ] Submission of Information Disclosure Statement
   [ ] Recording each patent assignment per property
   [ ] Request for Continued Examination
   [ ] Other: ____________________

TOTAL AMOUNT OF PAYMENT $ 450.00

Richard A. Schuth 10-28-05
Richard A. Schuth, Reg. No. 47,929 Date

RAS/skd

Express Mail Label No. EV 775629329 US

Express Mail Label
No. EV 775629329 US

MEMC 99-1250/2441.1
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Hariprasad Sreedharamurthy et al. Art Unit 1765
Serial No. 10/039,459
Filed November 7, 2001
Confirmation No. 1061

For APPARATUS AND PROCESS FOR THE PREPARATION OF LOW-IRON SINGLE CRYSTAL SILICON SUBSTANTIALLY FREE OF AGGLOMERATED INTRINSIC POINT DEFECTS

Examiner Matthew J. Song

SUBSTITUTED APPEAL BRIEF FOR APPELLANTS

Richard A. Schuth, Reg. No. 47,929
SENNIGER, POWERS, LEAVITT & ROEDEL
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400

TABLE OF CONTENTS

TABLE OF AUTHORITIES

REFERENCES

CASES

Express Mail Label
No. EV 775629329 US

MEMC 99-1250/2441.1
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Hariprasad Sreedharamurthy et al. Art Unit 1765
Serial No. 10/039,459
Filed November 7, 2001
Confirmation No. 1061

For APPARATUS AND PROCESS FOR THE PREPARATION OF LOW-IRON SINGLE CRYSTAL SILICON SUBSTANTIALLY FREE OF AGGLOMERATED INTRINSIC POINT DEFECTS

Examiner Matthew J. Song

BRIEF FOR APPELLANTS

This is an appeal from the final rejection of the above-identified application made in the Office action dated January 14, 2004. A Notice of Appeal was mailed on June 25, 2004.

i. REAL PARTY IN INTEREST

The real party in interest in connection with the present appeal is MEMC Electronic Materials Inc., owner of a 100 percent interest in the pending application.

ii. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any pending appeals or interferences which may directly affect or be directly affected by, or have a bearing on, the Board's decision in the pending appeal.

iii. STATUS OF CLAIMS

This application claims priority from U.S. provisional application Serial No. 60/258,296, filed on December 26, 2000.

Claims 1-14 are currently pending. In a Response to Restriction Requirement mailed on November 21, 2002, Applicant elected claims 1-14 for examination and withdrew claims 15-33 from consideration in Amendment A, dated March 21, 2003. At the same time, claims 10 and 14 were amended. A copy of the pending claims appears in the Claims Appendix.

Claims 1-14 stand rejected under 35 U.S.C. §103(a). The rejection of claims 1-14 under 35 U.S.C. §103(a) is being appealed.

iv. STATUS OF AMENDMENTS

No amendments have been filed after the final rejection.

v. SUMMARY OF CLAIMED SUBJECT MATTER

The following summary is provided in accordance with MPEP §1206 and correlates claim elements to specific embodiments described in the specification. Consistent with MPEP §1206, the following summary does not in any manner limit claim interpretation. Rather, the following summary is provided only to facilitate the Board's understanding of the subject matter of this appeal.

The present invention is directed to a crystal pulling apparatus for producing a silicon single crystals grown having a reduced level of metallic contamination, in particular an apparatus for the preparation of low-iron impurity single silicon crystals (*See* paragraph 0002 of published application US 2002/0144642 ('4642)).

Conventional crystal pulling apparatus often include graphite structural components. Impurities within these graphite structural components can evaporate and contaminate the crystal during grown. Because of this, graphite components within the hot zone of crystal pullers are commonly coated with a protective barrier layer, typically silicon carbide. (*See* paragraph 0006 of '4642).

Recently, "closed" hot zone configurations have been incorporated into crystal pullers to allow the growth of agglomerated intrinsic point defect free crystals. These "closed" hot zone configurations include additional structural components in the hot zone such as upper, intermediate and lower shields in the region above the crystal melt. Typically, these additional components are located in closer proximity to the ingot and cause the ingot to be maintained at higher temperatures for longer periods of time. Significantly, the increased amount of structural graphite, the higher temperatures, the closer proximity of structural components to the growing ingot and melt, and the longer duration of the pulling process can contribute to an increased amount of iron diffusing into the crystal. Because of this increased iron diffusion, crystals grown in "closed" hot

zone designs typically have iron concentrations near the peripheral edge (i.e., edge iron concentrations) which are at least 5 ppta to 10 ppta (parts per thousand atomic) and may be as high as 100 ppta. (*See* paragraphs 0007 and 0009 of '4642).

The present invention solves this problem by making the structural components in the crystal growth chamber such that they comprise a substrate and a protective layer covering the surface of the substrate, wherein the substrate comprises graphite and has a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3 and the protective layer comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3. (*See* paragraph 0022 of '4642). In a further embodiment, the invention also requires that the structural component is adapted for a typical growth chamber setting, i.e., the component is adapted to reach a temperature of at least about 950°C for a duration of at least about 80 hours and to be within about 3 cm to about 5 cm of the silicon single crystal or the silicon melt during ingot growth. Using the apparatus of the present invention, silicon ingots and wafers have been prepared with an edge iron concentration below about 5 ppta and even below about 0.8 ppta. (*See* paragraph 0024 of '4642).

vi. GROUNDS OF REJECTIONS TO BE REVIEWED ON APPEAL

A. Claims 1-9 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Holder et al. (WO 99/66108).

B. Claims 10 and 14 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Holder et al. in view of Falster et al. (U.S. 5,919,302) and Kim et al. (U.S. 5,942,032).

C. Claims 11-13 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Holder et al. in view of Falster et al. and Kim et al. as applied to claims 10 and 14 in view of Luter et al. (U.S. 5,922,127).

vii. ARGUMENT

A. Claims 1-9 are patentable under 35 U.S.C. §103 over Holder et al.

To render a claim obvious, the prior art reference (or references when combined) must teach or suggest all of the claim limitations.[1]

Claim 1 is directed to a crystal pulling apparatus for producing a silicon single crystal grown by the Czochralski process. The apparatus comprises a structural component disposed therein, which comprises a substrate and a protective layer covering the surface of the substrate that is exposed to the atmosphere of the growth chamber. The substrate comprises graphite which has a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3. The protective layer comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3.

Holder et al. disclose a crystal pulling apparatus comprising a growth chamber and a structural component disposed within the growth chamber. According to Holder et al., the structural component comprises graphite and has a protective layer covering the graphite. Holder et al. disclose that the graphite has less than about 20 ppm total metals such as iron, molybdenum, copper, and nickel, and preferably has less than about 5 ppm total metals.[2] Holder et al. also disclose that as the purity of the graphite increases, the amount of particle generation during high temperature heating decreases.[3] Additionally, Holder et al. disclose that the protective layer may comprise between about 99.9% to about 99.99% silicon carbide and between about 0.01% to about 0.1% silicon, which typically comprises about 1 ppma of iron.[4]

---

[1] MPEP 2143.

[2] Holder et al. at page 7, lines 10-16.

[3] Holder et al. at page 7, lines 16-18.

[4] Holder et al. at page 10, lines 25-33.

In contrast, Claim 1 requires that the concentration of iron in the substrates be **more than 10,000 times** lower than the preferred concentration allowed by Holder et al. In addition, the Office concedes that Holder et al. fail to disclose, teach, or suggest coating a graphite substrate with a silicon carbide protective layer having a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3, as required by claim 1. Accordingly, Holder et al. fail to disclose or suggest each and every one of claim 1's requirements.

To establish a *prima facie* case of obviousness there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference.[5] In the present case, there is no suggestion to modify the disclosure of Holder et al. to require that the graphite substrate and the silicon carbide layer have concentrations of iron no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. One possible source of such a suggestion to modify is the teaching of the prior art.[6] Although Holder et al. are concerned with controlling iron contamination of silicon by iron evolved from structural components, they do not teach or suggest reducing the concentration of iron in structural components. Rather, Holder et al. teach controlling iron contamination of the silicon ingot by gettering or capturing evolved metal impurities.[7] Specifically, Holder et al. disclose two methods of gettering metal impurities by utilizing the high affinity of silicon for such impurities. Holder et al.'s first embodiment comprises overlaying a silicon carbide or glassy carbon protective layer with a silicon layer.[8] The second embodiment comprises incorporating silicon with silicon carbide in a single protective coating.[9] As described above, the treatment of iron concentrations in the graphite and

[5] MPEP 2142, Third Paragraph.

[6] MPEP 2143.01 (*quoting In re Rouffet*, 149 F.3d 1350, 1357, 47 USPQ2d 1453, 1457-58 (Fed. Cir. 1998)).

[7] Holder et al. at page 4, lines 1-5; page 6, lines 15-22.

[8] Holder et al. at page 6, lines 8-15; and page 7, line 19 to page 8, line 6.

[9] Holder et al. at page 6, lines 8-15; and page 10, lines 15-24.

silicon carbide disclosed by Holder et al. is largely superficial and is consistent with their solution of controlling iron contamination of the ingot by gettering. Thus, Holder et al. do not teach or suggest decreasing the concentration of iron in the graphite and silicon carbide protective layer below conventional levels.

Moreover, the proposition stated in the Office action that "purifying an old product is held to be obvious" under MPEP 2144.04 VII does not render these claim requirements obvious. This section of the MPEP specifically acknowledges that "purer forms of known products may be patentable," and directs the Office to consider the following factors to assess patentability:

1) whether the claimed composition has the same utility as closely related materials in the prior art, and

2) whether the prior art suggests the claimed form, or

3) whether the prior art suggests methods of obtaining the claimed form.

Stated otherwise, for claim 1 to be obvious, the claimed composition must have the same utility as closely related materials in the prior art, and either the prior art would have to suggest the claimed form or the prior art would have to suggest methods of obtaining the claimed form. In the present case, all three factors taken separately or combined support a finding that the claimed subject matter is not obvious.

With regard to the first factor, the crystal pulling apparatus of claim 1 has a different utility than a crystal pulling apparatus disclosed by Holder et al. According to Court of Customs and Patent Appeals in *In re Cofer*, cited in MPEP 2144.04 VII, ". . . whether a given chemical compound or composition has the same usefulness as closely related materials may be an important consideration in determining obviousness under 35 U.S.C. 103."[10] Specifically, the crystal growing apparatus of claim 1 is used to produce a single crystal silicon ingot and wafers sliced therefrom that are substantially free of agglomerated defects <u>and</u> have a low degree of edge iron contamination (e.g.,

---

[10] *In re Cofer*, 148 USPQ 268, 271 (CCPA 1966). See also *In re Bergstrom* 166 USPQ 256, 262 (CCPA 1970) ("Whether the claimed pure materials have the same usefulness or assortment of properties as the impure materials of the prior art . . . is but one of the factors to be considered in determining the obviousness under 35 U.S.C. § 103.").

an apparatus comprising six low-iron structural components can produce silicon having an edge iron concentration that is less than about 5 parts per trillion atomic (ppta) and an average iron concentration that is less than about 3 ppta).[11] Such silicon is produced, in part, by decreasing the cooling rate of the growing ingot and maintaining the ingot at temperatures that keep intrinsic point defects mobile for longer periods of time. This is partly accomplished by designing the apparatus to have a closed hot zone that contains more structural components than an open hot zone. The additional structural components insulate the ingot, decreasing heat loss therefrom. As such, when growing silicon substantially free of agglomerated defects, the structural components are maintained at high temperatures for relatively long periods of time, increasing the propensity for iron to contaminate the ingot. In contrast to the claimed apparatus, a conventional crystal pulling apparatus comprising conventional structural components, as disclosed by Holder et al., cannot produce ingots that are substantially free of agglomerated defects without contaminating the silicon with an unacceptable amount of iron (e.g., silicon produced therewith will have average iron concentration of 5-10 ppta and an edge iron concentration as high as 100 ppta).[12] In view of the fact that the crystal pulling apparatus of claim 1 produces silicon that is qualitatively and quantitatively distinct from silicon produced using a crystal puller made of conventional structural components, the crystal puller of claim 1 has a different utility than that disclosed by Holder et al. This difference in utility supports a conclusion that claim 1 is not obvious under 35 U.S.C. 103.

---

[11]Paragraph 0024 of '4642.

[12]Paragraph 0009 of '4642.

With regard to the second factor, Holder et al. do not recognize the desirability of making a growth chamber of structural components having a substantially lower concentration of iron impurity, much less **10,000 times lower**. Although Holder et al. disclose that particle generation depends on graphite purity,[13] this characterization of conventional graphite cannot be fairly interpreted as a recognition or suggestion to reduce the concentration of metal contaminants to unconventional levels, such as less than about $1.5*10^{12}$ atoms/cm^3. In fact, rather than suggesting a significant reduction in impurities, the entire disclosure of Holder et al. is directed to controlling iron contamination of a silicon ingot by gettering or capturing metal impurities evolved from structural components.[14] Specifically, Holder et al. disclose two methods of gettering metal impurities by utilizing the high affinity of silicon for such contaminants. The first embodiment comprises overlaying a silicon carbide or glassy carbon protective layer with a silicon layer.[15] The second embodiment comprises incorporating silicon with silicon carbide in a single protective coating.[16] As described above, the treatment of iron concentrations in the graphite and silicon carbide disclosed by Holder et al. is largely superficial and is consistent with their solution of controlling iron contamination of the ingot by gettering. Thus, Holder et al. do not recognize or suggest the high degree of purity for the carbon substrate and protective layer as required by claim 1. Rather, Holder et al., suggests that it is not necessary to reduce the iron concentration, since the iron can be gettered by the protective coating.

With regard to the third factor, Holder et al. do not disclose any method for producing a structural component comprising a graphite substrate and a silicon carbide coating having the claimed iron concentrations. For example, claim 1 specifies that the graphite component has a concentration of iron that is no greater than about $1.5*10^{12}$ atoms/cm^3. This concentration is over 10,000 times below the 5 ppm concentration of

---

[13]Holder et al. at page 7, lines 16-18.

[14]Holder et al. at page 4, lines 1-5; page 6, lines 15-22.

[15]Holder et al. at page 6, lines 8-15; and page 7, line 19 to page 8, line 6.

[16]Holder et al. at page 6, lines 8-15; and page 10, lines 15-24.

conventional graphite. However, Holder et al. do not provide any direction as to the manner in which such an increase in graphite purity could be attained.

In *Ex parte Stern*[17], cited in MPEP 2144.04, the Board held the claimed homogenous (purified) human interleukin 2 to be obvious on the basis of conclusions analogous to the factors recited in the MPEP:

> 2) The Office provided evidence the product itself was disclosed or suggested in the art: "Skilled workers in this particular art have sought to purify IL-2 to homogeneity and apparently failed." "...there is a recognition in the art of the desirability of purifying IL-2 to homogeneity." 13 USPQ2d 1381.
>
> 3) The Office presented evidence of prior art methods to make the claimed product: "Pestka discloses a process employing high performance liquid chromatography capable of purifying to homogeneity proteins exhibiting molecular weights in excess of 12,000." 13 USPQ2d 1381.

With regard to the first factor, although not specifically discussed, the Applicant apparently failed to present evidence of any special utility beyond that of conventional IL-2. In contrast, the prosecution history of the immediate application (a) lacks any evidence of record of any suggestion in the prior art of the presently claimed structure, (b) lacks any evidence of record of any suggestion in the prior art of how to make the claimed structure, and (c) includes detailed explanation of the unexpected advantage the invention provides for facilitating production of wafers that are substantially free of agglomerated defects <u>and</u> have a low degree of edge iron contamination, as found in Applicants' specification. Accordingly, contrasting the facts of *Ex parte Stern* to the facts of the present application underscores that Applicants' claimed invention cannot fairly be deemed to be obvious as a "mere purification."

Further guidance is provided by the decision in *In re Cofer*, cited in MPEP 2144.04 VII. Referring to the three factors noted above, the CCPA reversed the Board's finding of obviousness because, even though there was evidence of the factor

[17] 13 USPQ2d 1379 (BPAI 1989).

(1) common utility, there was no evidence of the factor (2) suggestion in the art to make the enhanced compound or the factor (3) suggestion on how to make the enhanced compound. Similarly, in the present case the Office has not pointed to any factor (2) suggestion in the prior art to make the claimed enhanced structure, nor to any factor (3) suggestion in the prior art how to make the claimed enhanced structure. The present claims are therefore allowable for the same reasons as the claims in *In re Cofer*.

With regard to *Ex parte Gray*[18], cited in MPEP 2144.04, Applicants do not contest the proposition that "mere purity of a product by itself does not render the product unobvious." But in the present case, patentability is premised neither on the basis of "mere purity," nor on purity "by itself." The specific requirements of the claims with regard to purity, as described in detail above, facilitate production of wafers that are substantially free of agglomerated defects <u>and</u> have a low degree of edge iron contamination. This is an unexpected advantage; namely, an entirely distinct realm of capacity not available with structures having only conventional purity. Moreover, the purity level required in applicants' claims cannot fairly be deemed as "mere" purification, as neither the level itself nor a method of achieving it is suggested in the art.

Still further, there is a lack of motivation to modify Holder et al.'s support coating to have a low iron concentration as required by claim 1 because the iron contamination problem addressed by Holder et al. is distinct from the problem faced by the Applicants. The present invention is directed toward an apparatus used to produce silicon that is substantially free of agglomerated defects. Such silicon is produced, in part, by decreasing the cooling rate of the growing ingot and maintaining the ingot at temperatures that keep intrinsic point defects mobile for longer periods of time. This is partly accomplished by designing the apparatus to have a closed hot zone that contains more structural components than an open hot zone. The additional structural components insulate the ingot, thereby decreasing heat loss from the ingot. As such, when growing silicon substantially free of agglomerated defects, the structural components are maintained at high temperatures for relatively long periods of time,

[18] 10 USPQ2d 1022 (BPAI 1989).

increasing the propensity for iron to contaminate the ingot. The Applicants discovered that acceptable iron levels in the ingot could not be achieved using structural components with conventional iron concentrations in the substrate and coating. The Applicants discovered that to decrease the amount of iron in such an ingot, the concentration of iron in both the substrate and protective layer had to be dramatically reduced. To that end, the Applicants determined that iron concentrations within the substrate and protective layer had to be no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. Holder et al. were not faced with reducing iron contamination under such demanding process conditions and with the increased number of structural components of a closed hot zone, i.e., those problems facing the Applicants. As a result, Holder et al. were not motivated to decrease the iron concentrations in conventional structural components, let alone require the extremely low iron concentrations set forth in claim 1.

The Office also suggests that Larkin et al.[19] teaches a method of forming silicon carbide having a non-crystal element concentration of less than about $8*10^{13}$ cm^{-3}, which is a teaching of obtaining a purified silicon carbide crystal within the claimed range. However, the examiner disregards the fact that Larkin et al. discloses a method of controlling the amount of impurity incorporation in a crystal grown by a chemical vapor deposition process, not by the Czochralski process of the present invention. In fact, the method and apparatus used in Larkin et al. is completely different than the present invention.

In view of the foregoing, the Office has failed to present a *prima facie* case of obviousness because the cited art fails to disclose, teach, or suggest all the elements of claim 1. Specifically, the requirements of claim 1 that the concentrations of iron in the substrate and the protective layer be no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively, are not obvious. In addition, there is no suggestion or motivation in the references themselves or in knowledge generally available to one of ordinary skill in the art to modify the references to yield such requirements.

[19] Larkin et al. (U.S. Patent No. 5,709,745).

Claims 2-9 each depend directly or indirectly from claim 1 and, as such, are patentable for the same reasons as set forth above and in view of the additional requirements which they specify. For example, claims 2-6 are patentable for the same reasons as claim 1 and are further patentable over the cited art because the require even lower concentrations of iron in the substrate or the protective layer. Claims 7 and 8 are further patentable because they also require that the protective layer have a specified thickness. Claim 9 is further patentable because it also requires that the protective layer cover the entire surface of the substrate.

In view of the foregoing, the Office has failed to present a *prima facie* case of obviousness because the cited art fails to describe or suggest a crystal pulling apparatus comprising a structural component that comprises a graphite substrate having a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3 and a protective layer that comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3. As such, claim 1-9 are submitted as patentable.

B. Claims 10 and 14 are patentable under 35 U.S.C. §103 over Holder et al. in view of Falster et al. and Kim et al.

Claims 10 depends directly from claim 1 and, as such, it is patentable over Holder et al. for the same reasons as discussed above with regard to claim 1. Specifically, Holder et al. fail to describe or suggest any apparatus comprising structural components having a substrate and protective layer such that the concentrations of iron in the substrate and the protective layer are no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. Moreover, neither Falster et al. nor Kim et al. describe or suggest such an apparatus or discuss any structural components of an apparatus having such iron concentrations. Indeed, the Office makes no such assertion. As such, Falster et al. and Kim et al., whether considered alone or in combination, fail to cure the deficiencies of Holder et al.

As with claim 1, claim 14 is directed to a crystal pulling apparatus for producing a silicon single crystal grown by the Czochralski process. The structural component comprises a substrate and a protective layer covering the surface of the substrate

inside the growth chamber. The substrate comprises graphite which has a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3. The protective layer comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3. Furthermore, claim 14 requires that the structural component be adapted to reach a temperature of at least about 950°C for a duration of at least about 80 hours and to be within about 3 cm to about 5 cm of the silicon single crystal or a silicon melt during the growth of the silicon single crystal.

For the same reasons detailed above with regard to claim 1, the Office has failed to present a *prima facie* case of obviousness because the cited art fails to describe or suggest a crystal pulling apparatus comprising a structural component that comprises a graphite substrate having a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3 and a protective layer that comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3. Moreover, neither Falster et al. nor Kim et al. describe or suggest such an apparatus or discuss any structural components of an apparatus having such iron concentrations. As such, Falster et al. and Kim et al., whether considered alone or in combination, fail to cure the deficiencies of Holder et al.

C. Claims 11-13 are patentable under 35 U.S.C. §103 over Holder et al. in view of Falster et al. and Kim et al. in view of Luter et al.

Claims 11-13 each depend indirectly from claim 1 as such are patentable over Holder et al. for the same reasons as discussed above with regards to claim 1. Specifically, Holder et al., fail to describe or suggest any apparatus comprising structural components having a substrate and protective layer such that the concentrations of iron in the substrate and the protective layer be no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. Moreover, none of the other cited references, Falster et al., Kim et al., or Luter et al. describe or suggest such an apparatus or even discuss any structural components having such iron concentrations. Indeed, the Office makes no such assertion. As such, Falster et al., Kim et al.. and Luter et al., whether considered alone or in combination, fail to cure the deficiencies of Holder et al.

D. CONCLUSION

A *prima facie* case of obviousness has not been established pursuant to 35 U.S.C. § 103, because the cited art fails to disclose, teach, or suggest all the elements of claim 1-14. For these reasons, Applicants respectfully request the Office's rejections be reversed and claims 1-14 be granted.

* A check for $450.00 is enclosed for a two month extension of time. The Commissioner is hereby authorized to charge any additional fees which may be required to Deposit Account No. 19-1345.

Respectfully submitted,

Richard A. Schuth, Reg. No. 47,929
SENNIGER, POWERS, LEAVITT & ROEDEL
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400

RAS/DER/skd
*Enclosures

viii. CLAIMS APPENDIX

1. A crystal pulling apparatus for producing a silicon single crystal grown by the Czochralski process, the apparatus comprising:

a growth chamber; and

a structural component disposed within the growth chamber, the structural component comprising a substrate and a protective layer covering the surface of the substrate that is exposed to the atmosphere of the growth chamber, the substrate comprising graphite and having a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3, the protective layer comprising silicon carbide and having a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3.

2. The crystal pulling apparatus as set forth in claim 1 wherein the concentration of iron in the substrate is no greater than about $1.0*10^{12}$ atoms/cm^3.

3. The crystal pulling apparatus as set forth in claim 1 wherein the concentration of iron in the substrate is no greater than about $0.5*10^{12}$ atoms/cm^3.

4. The crystal pulling apparatus as set forth in claim 1 wherein the concentration of iron in the substrate is no greater than about $0.1*10^{12}$ atoms/cm^3.

5. The crystal pulling apparatus as set forth in claim 1 wherein the concentration of iron in the protective layer is no greater than about $0.5*10^{12}$ atoms/cm^3.

6. The crystal pulling apparatus as set forth in claim 1 wherein the concentration of iron in the protective layer is no greater than about $0.1*10^{12}$ atoms/cm^3 of iron.

7. The crystal pulling apparatus as set forth in claim 1 wherein the protective layer is about 75 to about 125 μm thick.

8. The crystal pulling apparatus as set forth in claim 1 wherein the protective layer is about 100 μm thick.

9. The crystal pulling apparatus as set forth in claim 1 wherein the protective layer covers the entire surface of the substrate.

10. The crystal pulling apparatus as set forth in claim 1 wherein the structural component is adapted to reach a temperature of at least about 950 °C for a duration of at least about 80 hours and to be within about 3 cm to about 5 cm of the silicon single crystal or a silicon melt during the growth of the silicon single crystal.

11. The crystal pulling apparatus as set forth in claim 10 wherein the structural component is selected from the group consisting essentially of an upper heater, an upper heater shield, an intermediate heat shield, a lower heat shield inner reflector, a

lower heat shield outer reflector, a lower heat shield insulation layer, an upper insulation support and an upper insulation shield.

12. The crystal pulling apparatus as set forth in claim 11 comprising at least six structural components selected from the group.

13. The crystal pulling apparatus as set forth in claim 11 comprising at least eight structural components selected from the group.

14. A crystal pulling apparatus for producing a silicon single crystal grown by the Czochralski process, the apparatus comprising:

a growth chamber; and

a plurality of structural components disposed within the growth chamber that are adapted to reach a temperature of at least about 950 °C for a duration of at least 80 hours and to be within about 3 cm to about 5 cm of the silicon single crystal or a silicon melt during the growth of the silicon single crystal, each structural component comprising a substrate and a protective layer covering the surface of the substrate that is exposed to the atmosphere of the growth chamber, the substrate comprising graphite and having a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3, the protective layer comprising silicon carbide and having a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3.

ix. EVIDENCE APPENDIX

None.

x. RELATED PROCEEDINGS APPENDIX

None.